STUDY OF THE ELECTRICAL IMPEDANCE SCANNING

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Abstract- **The Electrical Transimpedance Scanning is a new modality of image based on the differences in electrical properties of tissues. It is an extremely promising technique to complement other conventional image examinations. Areas presenting abnormalities and/or malignant neoplasia evidence exhibit conductive changes that cause an impedance variation between cancerous ant health tissues. Since there are very few commercial devices available that use the new Electrical Transimpedance Scanning technology, this paper describers the design of a prototype using this technique aiming to contribute somehow in the evaluation of the parameters involved.**

Keywords **– Electrical Transimpedance Scanning, Breast cancer**

I. INTRODUCTION

The Electrical Transimpedance Scanning (ETS) is a new technique, non-invasive, non-irradiant, used in the diagnosis of breast cancer. Combined with other conventional techniques such as ultrasonography and mammography, it helps increasing the probability of obtaining an early diagnosis of breast cancer [5].

In young women, whose breast tissue is denser, abnormalities and suspect areas are not properly shown by conventional mammography**.** This occurs mainly because in such dense tissues the penetration of X-rays is not deep enough, causing less difference in attenuation and creating, as a result, an image with less contrast between the abnormal area and the health tissue. ETS is a technique based on the electrical properties of tissues (impedance, conductivity, permissivity etc.) and the literature has shown its efficiency in research process and clinical evaluation of small lesions in young women with dense breast tissue [4]. Table 1 shows the relatives values of sensitivity, specificity, positive predictive value and negative predictive value for each technique (mammography and T-scan), together and separated [6].

TABLE 1

Some comparative parameters

parameters	Techniques			
	Mammography	EIS	Adjunctive	p-value
Sensitivity	82%	69%	86%	<0.1
Specificity	39%	45%	51%	<0.0001
PPV	43%	42%	49%	<0.01
NPV	80%	78%	87%	<0.01

PPV = positive predictive value
NPV = negative predictive value

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The measures of electrical impedance for scanning are based on the distribution of the electrical field of specific tissues and in the measurability of one of the electrical parameters on the surface of the body at the area of interest [1]. Normally, a low level of electric current is used to produce, in real time, functional images of the electrical impedance properties of the tissues.

In fact, when we measure the impedance of a tissue we are measuring its conductivity or conductance and/or permissivity or reactance [3]. Areas presenting abnormalities and/or malignant neoplasia evidence exhibit conductive changes (in the structure of cell's membrane, in its permeability, in the amount of water inter and extra cells, in the electrolytic content) that cause an impedance variation between cancerous ant health tissues. Normal tissues present a high impedance (low conductivity) when compared to malign tissues (cancerous) [2].

Since there are very few commercial devices around the world that use the new Electrical Transimpedance Scanning technology, the Biomedical Engineering Laboratory at Coppe/UFRJ, decided to dedicate itself to the study of this technique, aiming to contribute somehow in the evaluation of the parameters involved. The present study describes the development of an ETS- prototype, focusing aspects related to the system instrumentation and the first obtained results.

II. METHODOLOGY

The ETS system consists in an excitation source current, or voltage, injected by a cylindrical electrode, usually held by the patient, and a set of measurement pre-amplifiers connected to a group of electrodes, that constitute the sensor part. This system is illustrated in Fig. 1.

Fig.1.This figure shows the patient holding a metallic wand and the technologist holding the scanning probe against the patient's breast in order to get the data to generate the ETS image.

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Abstract

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The prototype's sensor is somehow similar to the few ones related in the medical literature, i.e., it presents 64 pixels resolution, although commercially there are already systems working with 256 pixels probe. The 64 pixels resolution is obtained from a matrix (8X8) electrodes, in which each electrode has a 1X1 mm^2 area, a 9 mm distance between its centers and a 2.5 mm space between adjacent electrodes. The electrodes are connected to transimpedance (2.67KΩ) pre-amplifiers specially projected to this study arranged in 4 boards with 16 pre-amplifiers each, in a total number of 64 pre-amplifiers. The pre-amplifiers outputs were connected to an AD acquisition board with 16 bits, 8 channels, 100kHz (Computer Board, DAS16-16S) through a 16 channels multiplex, also specially projected for the present study. The images are acquired and displayed in a specially developed program (LabVIEW) able to produce, three frames per second. Fig. 2 shows the block diagram of the developed system.

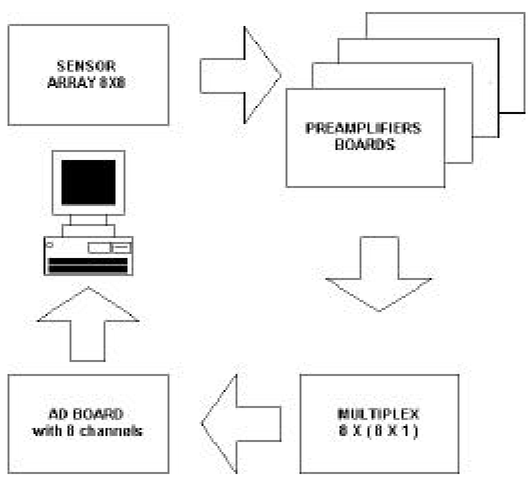

Fig.2. Block diagram of the developed system

In order to investigate the influence of the excitation-voltage frequency in the image resolution the range of 100Hz to 10kHz was scanned.

For experimental tests of the prototype, an agar-agar phantom was built to simulate the breast conjunctive tissue, where the cancerous cells were implemented as little targets with different electrical properties (conductors and isolators).

The agar-agar phantom sited 40mmX40mmX15mm. The target simulation the cancerous area was put approximately at 3mm from the surface and its sizes was changed in the range 1mm to 7mm. Fig.3 illustrates the phantom used in the experimental tests.

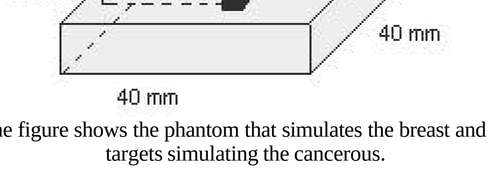

Fig.3.The figure shows the phantom that simulates the breast and the little targets simulating the cancerous.

III. RESULTS AND DISCUSSION

Initially a manual sweep was made in the sinusoidal voltage-excitation frequency in order to observe its influence in the image resolution. Figures 4, 5, 6 and 7 show an area without target, the target area with a 100Hz of excitation, the target area with a 1kHz of excitation and a target area with 10KHz of the sinusoidal excitation, respectively. It can be seen the best image resolution was obtained when the voltage-excitation frequency was set to 10KHz.

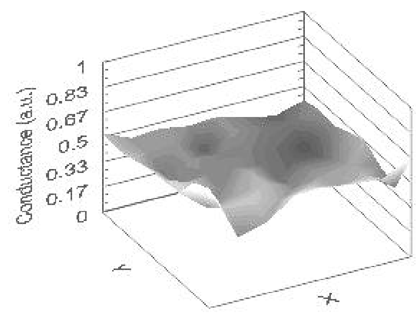

Fig.4. Conductance map for a phantom's area without target.

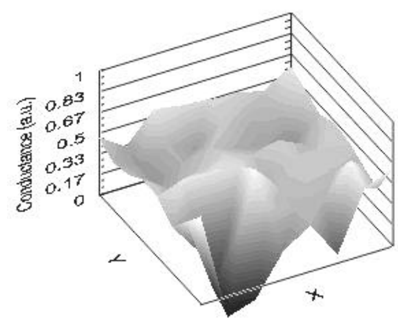

Fig.5.Conductance map for a 7.0x5.0 mm^2 target with voltage-excitation frequency of 100 Hz.

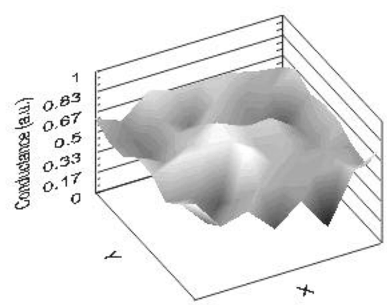

Fig.6. Conductance map for a 7.0x5.0 mm^2 target with voltage-excitation frequency of 1kHz.

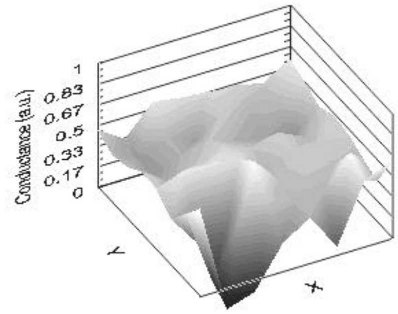

Fig.7. Conductance map for a 7.0x5.0 mm^2 target with voltage-excitation frequency of 10kHz.

After the choosing of the best operation frequency, a manual sweep in the voltage-excitation amplitude was performed. Preliminary results point out the amplitude doesn't present a great influence in the image resolution. However, small amplitude ($\leq 2.28V_{p-p}$) leads to a poor signal to noise ratio and degradation in image resolution. Great amplitudes ($>20V_{p-p}$) lead to an increasing in the electrodes' impedance and consequently a worst image due to the fact the current sharing will depend not only the phantom, but also those impedance. Fig.8 shows the best image obtained at frequency of 10kHz and $18.4V_{p-p}$.

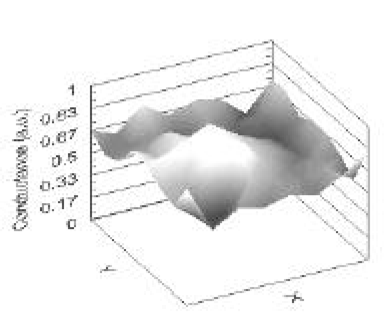

Fig.8. The best image obtained at the frequency of 10kHz and amplitude of $18.4V_{p-p}$.

IV. Conclusion

Although some papers have presented the best operation frequency for ETS systems as 100-200 Hz [1], in the present study the best results were obtained around 10kHz. This fact can be explained considering the differences between the electrical characteristics of the adipose and cancerous tissues, in the real case, and the agar-agar and targets, in the phantom. In the first case the maximization between the normal and the abnormal tissues is obtained around 100Hz, due to the variation of the conductive with the frequency [1]. In the second case the best image will depend on the ratio between the total phantom impedance and the electrode impedance. As the latter decreases with the frequency it was expected the best results were obtained to the greater swept frequency. We decide not to increase the frequency over 10kHz due to the 100kHz sample frequency.

One can conclude the objective of design a ETS prototype succeeded. Since there are few commercial systems available using this new technology, the studies on ETS systems can guide the design of better and less expensive systems. Future steps include the construct of the imaginary part of the conductance and a phase-lag map.

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